Lat 39.30347 Lon -120.87574

Forest Health Protection

Pacific Southwest Region
Northeastern California Shared Service Area

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To: District Ranger, Yuba River Ranger District, Tahoe National Forest

Subject: Insect and Disease Evaluation of the Western Nevada County Community Defense Project – Deer Creek (FHP Report NE14-06)

At the request of Beth Stewart, Silviculturist, Vegetation Management Solutions, Danny Cluck, Forest Health Protection (FHP) Entomologist, and Bill Woodruff, FHP Plant Pathologist, conducted a field evaluation of Western Nevada County Community Defense Project – Deer Creek on October 7, 2014. The objective was to evaluate the current forest health conditions within the project area, discuss what influence these conditions would have on stand management objectives and provide recommendations as appropriate. Beth Stewart accompanied us to the field.

Key findings:

- Forest stands are generally overstocked with high levels of surface and ladder fuels.
- Drought induced needle cast was observed on all conifer species.
- Current tree mortality is minimal throughout the project area. Tree species observed with recent bark beetle activity were limited to ponderosa pine and white fir.
- A few young incense cedar are dying in response to current drought conditions.
- The risk of bark beetle-caused mortality is highest in older ponderosa pine plantations where stand density is reaching or exceeding susceptible levels.
- Heterobasidion root disease was found in White Cloud campground in white fir. Infection centers are contributing to tree mortality as well as creating tree hazards.
- Thinning, mastication and underburning are proposed throughout the project area to reduce tree density and surface and ladder fuel levels. Specific recommendations are provided in this evaluation.

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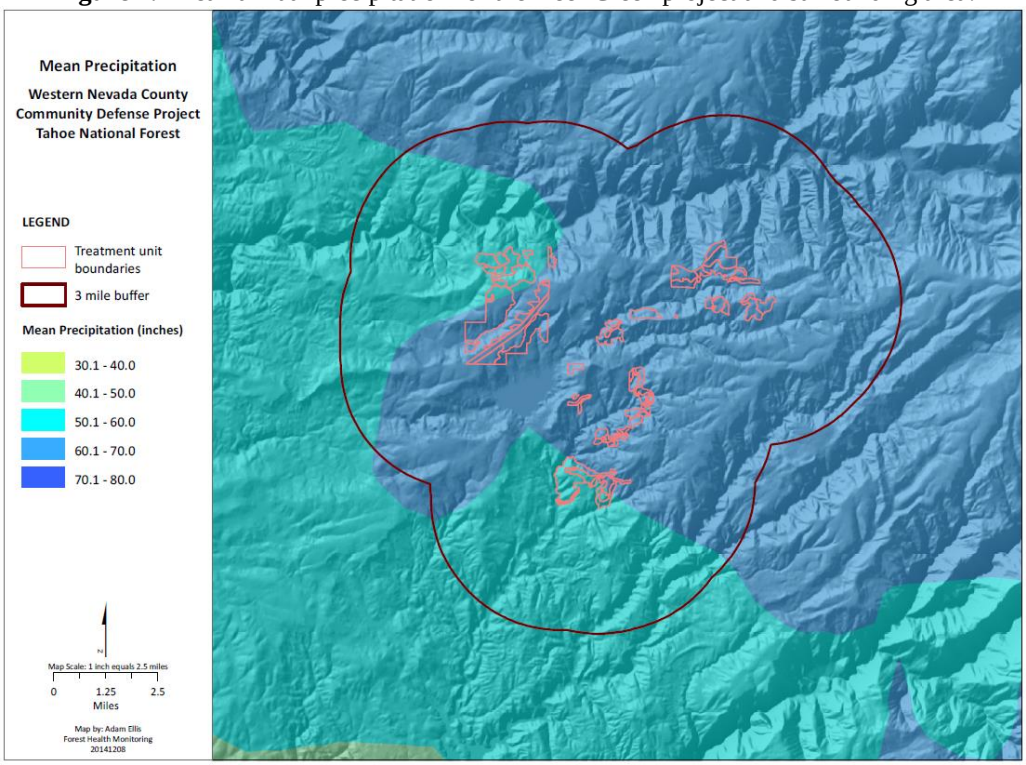
Description of the project area

The Western Nevada County Community Defense Project – Deer Creek (referred to as the "Deer Creek Project" for the remainder of this report) is located approximately 4 miles east of Nevada City, CA at elevations ranging between 2,600 and 4,800 feet (39.303468N and 120.875743W). Annual precipitation ranges between 50 and 70 inches (Figure 1). Most of the area is comprised of Sierra mixed conifer consisting of Douglas-fir (*Pseudotsuga menziesii*), ponderosa pine (*Pinus ponderosa*), white fir (*Abies concolor*), sugar pine (*Pinus lambertiana*), and incense cedar (*Calocedrus decurrens*). California black oak (*Quercus kelloggii*), Pacific madrone (*Arbutus menziesii*), tanoak (*Notholithocarpus densiflorus*), and Pacific yew (*Taxus brevifolia*) are found at lower elevations.

Figure 1. Mean annual precipitation for the Deer Creek project and surrounding area.



Forest stand conditions

Many areas are stocked with high numbers of small diameter trees. While these trees contribute to overall stand density, they primarily contribute to excessive fuel loading. Some project areas are also densely stocked with larger diameter trees and relatively open understories (Figure 2). Ponderosa pine plantations found within the project area are overstocked and at high risk to western pine beetle-caused mortality (Figure 3).

Figure 2. Overly dense mixed conifer stand near White Cloud campground.

Management objectives

The Deer Creek project proposes to reduce fuels and improve forest health through thinning. Most stands will have small diameter trees and shrubs reduced while other stands will require the removal of larger trees to reduce stocking and make stands more resilient to drought, insects and disease. White fir will be removed in favor of retaining other tree species in most situations. Black oak will be released by removing competing conifers. The residual stands will be more open, increasing the amount of available soil moisture and sunlight for individual trees.

Figure 3. Dense ponderosa pine plantation at risk to western pine beetle-caused mortality.

Forest insect and disease conditions

Current bark beetle activity is limited primarily to ponderosa pine where western pine beetle (*Dendroctonus brevicomis*) is causing low levels of scattered tree mortality. Fir engraver beetle (*Scolytus ventralis*) activity can be found in white fir on drier sites and in association with Heterobasidion root disease (caused by *Heterobasidion occidentale*, formerly referred to as S-type annosus root disease) (Figures 4 and 5). Confirmed and suspected Heterobasidion root disease pockets were located within White Cloud campground (Figure 6).

Figure 4. White fir killed by fir engraver beetle (left) and heavily infected with dwarf mistletoe (right).

Other tree diseases observed within the project area include western gall rust (*Peridermium harknessii*) in ponderosa pine and dwarf mistletoe (*Arceuthobium abietinum* f. sp. *concoloris*) in white fir (Figure 4). Pacific madrone also appeared to be affected by stem and branch cankers (caused by one or more fungal species) but was not confirmed. All of these act as added stressors to infected trees but are not causing significant damage at this time.

Figure 5. White boring dust from fir engraver attacks on root disease infected white fir.

In addition to pest observations made during this site visit, Forest Health Protection Aerial Detection Survey (ADS) data from 2014 revealed scattered pockets of conifer and

hardwood mortality within and adjacent to the Deer Creek project area. Affected species include sugar pine, ponderosa pine, Douglas-fir (killed by bark beetles) and Pacific madrone (cause unknown) (Figure 7).

Stand conditions and mortality related to recent and future climate trends

Many of the forested areas in the Deer Creek project appear to be overstocked and have sustained low levels of bark beetle-caused mortality based on ADS data over the past 10 years (Figure 8). There are also many areas where no mortality was mapped during this time. However, this does not necessarily indicate the existence of healthy forest conditions. Many stands within this "mortality free" zone are at an elevated risk to bark beetle and/or root disease-caused tree mortality due to overstocked conditions and could experience unacceptable levels of tree mortality during future droughts.

Figure 6. White fir stump with fruiting body (conk) of *Heterobasidion occidentale* in White Cloud campground.

Figure 7. 2014 Aerial Detection Survey tree mortality by species.

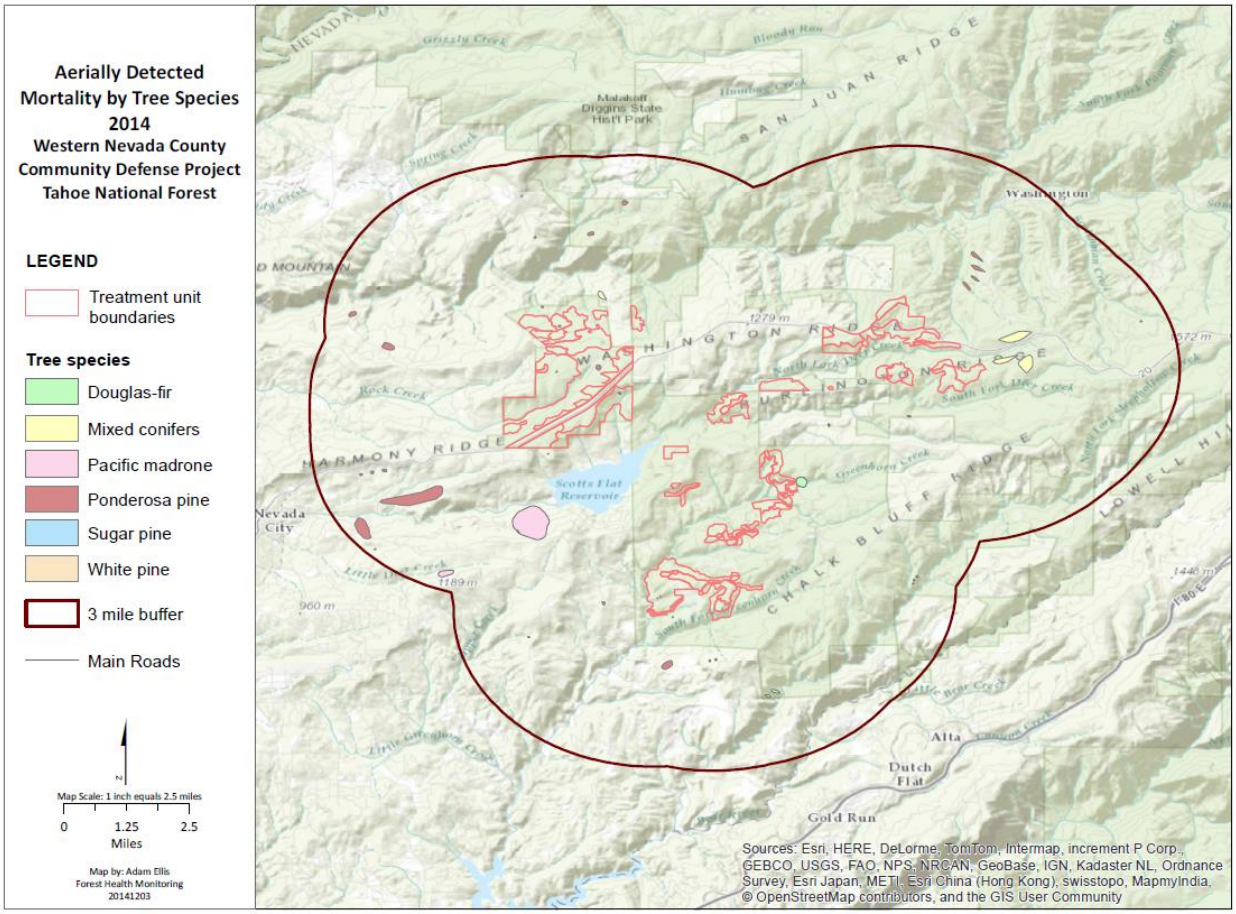
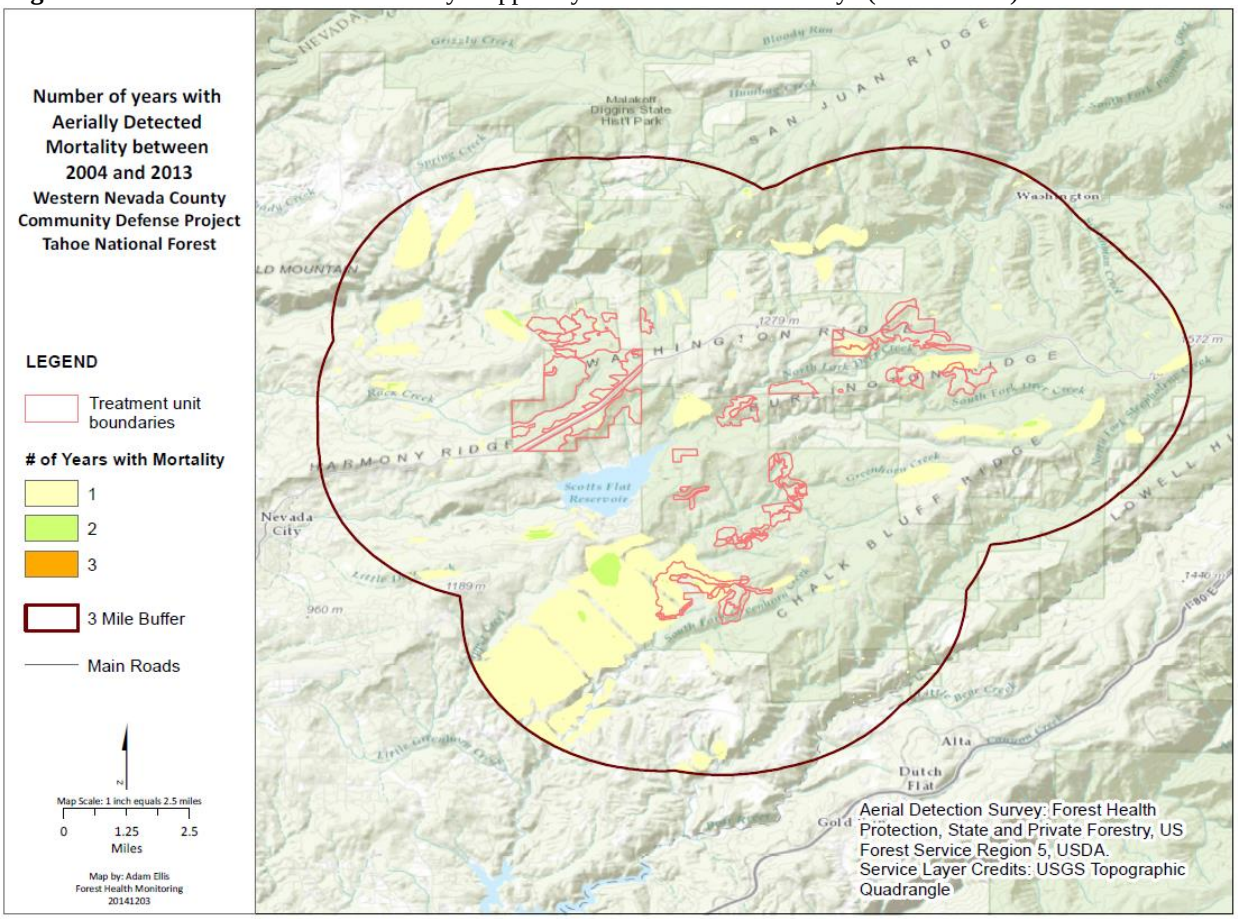


Figure 8. Areas of elevated tree mortality mapped by Aerial Detection Surveys (2004 – 2013).



Predicted climate change is likely to impact trees growing in the Deer Creek over the next 100 years. Although no Tahoe National Forest specific climate change models are available at this time, there is a general consensus among California models that summers will be drier than they are currently. This prediction is based on the forecasted rise in mean minimum and maximum temperatures and remains consistent regardless of future levels of annual precipitation (K. Merriam and H. Safford, *A summary of current trends and probable future trends in climate and climate-driven processes in the Sierra Cascade Province, including the Plumas, Modoc, and Lassen National Forests*). Under this scenario, the risk of bark beetle-caused tree mortality, especially for drought intolerant white fir, will likely increase for all conifer species. Improving the resilience of stands to future disturbance events through density, size class and species composition management will be critical to maintaining a healthy forested landscape.

Considerations for thinning treatments

Tree mortality directly attributable to insects and/or pathogens is occurring at low levels within the Deer Creek project area. This condition is typical for mixed conifer stands on the west side of the Sierra Nevada range due to the very high annual precipitation and high site quality. However, many stands are overstocked and have sustained elevated levels of bark beetle-caused mortality during recent droughts.

The thinning prescription proposed for mixed conifer stands aims to reduce stocking to an average basal area of 130 to 160 sq.ft./acre. This treatment should effectively reduce inter-tree competition for limited water and nutrients and reduce the risk of insect and disease-caused mortality for most areas. The exception to this would be drier south facing upper slopes which may require more extensive thinning to achieve appropriate stocking levels.

Dense ponderosa pine plantations pose the greatest threat for unacceptable levels of bark beetle-caused mortality within the Deer Creek project area. These stands would benefit by an overall reduction in stand density with an emphasis placed on maintaining and enhancing conditions for other species such as Douglas-fir, sugar pine, madrone and black oak. The thinning prescription proposed for the plantations will reduce basal area to an average of 80 to 120 sq.ft./acre. This should effectively reduce the risk of significant western pine beetle-caused mortality.

The proportion of white fir found within the Deer Creek project area has increased through past management activities and with the exclusion of fire over the past 100+ years. As a result, shade intolerant species such as ponderosa pine and black oak, as well as many shrub species, tend to decline due to competition for sunlight, water and nutrients. Higher percentages of white fir in mixed conifer stands can also increase susceptibility to defoliation events caused by the Douglas-fir tussock moth. In California, white fir is the preferred host species for the Douglas-fir tussock moth and outbreaks have tended to occur on ridge tops, upper slopes and generally poorer sites stocked with high percentages of white fir. Past outbreaks where heavy defoliation has occurred resulted in approximately 20 - 25% mortality with lower levels of top kill. Management practices that increase stand vigor, increase species diversity and promote an even-aged white fir component will increase resistance to Douglas-fir tussock moth.

When planning thinning treatments, it should be recognized that the target stand density is an average to be applied across the landscape and some variability may be desired. Individual high value trees, such as mature pines and oaks should benefit by having the stocking around them reduced to lower levels. Allowing for denser tree spacing and pockets of higher canopy cover may be desirable around potential wildlife trees, such as forked and/or broken-topped trees. Small group harvest could also be utilized to remove white fir that are within known Heterobasidion root disease centers or are heavily infected with dwarf mistletoe; thereby providing opportunities for planting non-host species. Incorporating the concepts of GTR 220 will address many of these issues and be consistent with Region 5 ecosystem restoration goals. Many of these methods are also consistent with past Forest Health Protection recommendations for thinning in mixed conifer stands and their use is supported for the Deer Creek project.

Heterobasidion occidentale (fir type Heterobasidion root disease) appears to be occurring at low levels within the project area. Since there may be large portions of white fir stands that have low levels of root disease or are possibly free of root disease, it is recommended that a registered borate compound be applied to all freshly cut true fir stumps >14” in diameter to reduce the chance of creating new infection centers through harvest activity. If further recon reveals more extensive root disease within harvest units, the treatment of white fir stumps may be ineffective. The treatment of all other conifer species stumps >14” in diameter, created through harvest activity, is recommended for the entire Deer Creek project area.

Considerations for Rx fire

If prescribed fire is used as a follow-up treatment to stand thinning or as a standalone treatment, unacceptable levels of large diameter pine mortality may occur depending on management objectives. This mortality most often occurs as a direct result of cambium or crown injury to individual trees during the fire. Mature ponderosa and especially sugar pines are susceptible to mortality during prescribed burns because of the deep duff and litter that has accumulated at their base in the absence of fire. These duff mounds typically burn at a slow rate, while maintaining lethal temperatures, causing severe cambium injury. To protect individual large diameter pine from lethal cambium injury, raking the duff away from the bases of these trees before burning (within 24" of the bole and down to mineral soil) is recommended.

Considerations for hazard trees at White Cloud campground and other high-use areas

Roadside and recreation areas within the Deer Creek project area invite the public to stop, take pictures, hike, picnic and spend extra time within forested areas. This increases Forest Service liability in regards to hazard trees. The presence of Heterobasidion root disease in white fir in the White Cloud campground suggests that there may be other potentially hazardous white fir within the Deer Creek project area. To abate potential hazards, white fir with suspected root disease should be removed whenever a target (people or property) exists. To assess trees for root disease, it is reasonable to use the condition of the crown as an indicator of advanced decay. Although not always caused by root decay, a thin crown and/or short leader growth does indicate poor tree vigor. A tree with reduced photosynthesis is not able to maintain healthy roots as well as a tree with a full and healthy crown. In the presence of root disease, unhealthy roots will likely be overcome with decay faster than vigorously growing roots. For this reason, the thinner the crown of a tree in an area where root disease is confirmed, the more likely it is that the roots have been weakened by decay.

Despite the effectiveness of any long or short-term plans to prevent tree injury and mortality, some trees, through declining health, will eventually become hazards to the public. To minimize the risks, hazard trees should be identified and removed before they fail. The current practice for many National Forest campgrounds is to remove trees as they die. This eliminates the risk from dead trees but fails to address living trees that are infected with root disease, heart rot, and/or have a structural defect. These high-risk green trees are equally hazardous and should not be overlooked. Therefore, it is recommended that the Forest develop a hazard tree evaluation and monitoring plan for these recreation areas. At your request, Forest Health Protection can provide information and assist with the development of this plan. FHP guidelines for hazard tree identification and management are available on the Region 5 FHP website: http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5332560.pdf

In the short-term, trees that have obvious stem decay, dead tops and/or large dead branches or exhibit a declining crown condition within established root disease centers and are within striking distance of a target should be carefully evaluated and hazards removed or pruned as soon as possible. All standing dead trees within striking distance of any target should be removed immediately.

If you have any questions regarding this report and/or need additional information please contact Danny Cluck at 530-252-6431 or Bill Woodruff at 530-252-6680.

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Insect and Disease Information

Western Pine Beetle

The western pine beetle, *Dendroctonus brevicomis*, has been intensively studied and has proven to be an important factor in the ecology and management of ponderosa pine throughout the range of this host species (Miller and Keen 1960). This insect breeds in the main bole of living ponderosa pine larger than about 8 inches dbh. Normally it breeds in trees weakened by drought, overstocking, root disease, dwarf mistletoe or fire. Adult beetles emerge and attack trees continuously from spring through fall. Depending on the latitude and elevation, there can be from one to four generations per year.

Evidence of Attack

Initial attacks are made about mid-bole and subsequent attacks fill in above and below. Pitch tubes are formed on the tree trunk around the entry holes. The pitch tubes are red-brown masses of resin and boring dust. Relatively few, widely scattered, white pitch tubes usually indicate that the attacks were not successful and that the tree should survive. Pheromones released during a successful attack attract other western pine beetles. Attacking beetles may spill over into nearby apparently healthy trees and overwhelm them by sheer numbers.

Life Stages and Development

These beetles pass through the egg, larval, pupal and adult stages during a life-cycle that varies in length dependent primarily upon temperature. Adults bore a sinuous gallery pattern in the phloem and the female lays eggs in niches along the sides of the gallery. The larvae are small white grubs that first feed in the phloem and then mine into the middle bark where they complete most of their development. Bluestain fungi, introduced during successful attacks, contribute to the rapid tree mortality associated with bark beetle attacks.

Conditions Affecting Outbreaks

Outbreaks of western pine beetle have been observed, and surveys made, in pine regions of the West since 1899 (Hopkins 1899; cited in Miller and Keen 1960). An insect survey completed in 1917 in northern California indicated that over 25 million board feet of pine timber had been killed by bark beetles. Information from surveys initiated in the 1930s indicates that there were enormous losses attributed to western pine beetle around that time. During the 1930's outbreak, most of the mortality occurred in stands of mature or overmature trees of poor vigor (Miller and Keen 1960). Group kills do not typically continue to increase in size through successive beetle generations as is typical with Jeffrey pine beetle. Rather, observations indicate that emerging beetles tend to leave the group kill area to initiate new attacks elsewhere.

The availability of suitable host material is a key condition influencing western pine beetle outbreaks. In northeastern California, drought stress may be the key condition influencing outbreaks. When healthy trees undergo a sudden and severe moisture stress populations of western pine beetle are likely to increase. Healthy trees ordinarily produce abundant amounts of resin, which pitch out attacking beetles, but when deprived of moisture, stressed trees cannot produce sufficient resin flow to resist attack. Any condition that results in excessive demand for moisture, such as tree crowding, competing vegetation or protracted drought periods; or any condition that reduces that ability of the roots to supply water to the tree, such as mechanical damage, root disease, or soil compaction, can cause moisture stress and increase

susceptibility to attack by the western pine beetle. Woodpeckers and predaceous beetles are natural control agents when beetle populations are low.

Fir engraver beetle

The fir engraver attacks red and white fir in California. Fir engraver adults and developing broods kill true firs by mining the cambium, phloem, and outer sapwood of the bole, thereby girdling the tree. Trees greater that 4" in diameter are attacked and often killed in a single season. Many trees, weakened through successive attacks, die slowly over a period of years. Others may survive attack as evidenced by old spike-topped fir and trees with individual branch mortality. Although many other species of bark beetles cannot develop successful broods without killing the tree, the fir engraver beetle is able to attack and establish broods when only a portion of the cambium area has been killed.

Evidence of Attack

Fir engravers bore entrance holes along the main stem, usually in areas that are > 4" in diameter. Reddish-brown or white boring dust may be seen along the trunk in bark crevices and in spider webs. Some pitch streamers may be indicative of fir engraver attacks; however, true firs are known to stream pitch for various reasons and there is not clear evidence that pitch streamers indicate subsequent tree mortality or successful attack. Resin canals and pockets in the cortex of the bark are part of the trees defense mechanism. Beetle galleries that contact these structures almost always fail to produce larval galleries as the adults invariably abandon the attack. Pitch tubes, often formed when bark beetles attack pine, are not produced on firs.

Adults excavate horizontal galleries that engrave the sapwood; the larval galleries extend at right angles along the grain. Attacks in the crown may girdle branches resulting in individual branch mortality or "flagging". Numerous attacks over part or the entire bole may kill the upper portion of the crown or the entire tree. A healthy tree can recover if sufficient areas of cambium remain and top-killed trees can produce new leaders. The fir engraver is frequently associated with the roundheaded fir borer and the fir flatheaded borer.

Life Stages and Development

In the summer, adults emerge and attack new host trees. The female enters the tree first followed by the male. Eggs are laid in niches on either side of the gallery. Adult beetles carry the brown staining fungi, *Trichosporium symbioticum*, into the tree that causes a yellowish-brown discoloration around the gallery. The larvae mine straight up and down, perpendicular to the egg gallery. Winter is commonly spent in the larval stage, with pupation occurring in early spring. In most locations, the fir engraver completes its life cycle in 1 year; however at higher elevations 2 years may be required.

Conditions Affecting Outbreaks

Fir engravers bore into any member of the host species on which they land but establish successful galleries only in those that have little or no resistance to attack. Populations of less aggressive species like fir engraver are likely to wax and wane in direct relationship to the stresses of their hosts. Drought conditions often result in widespread fir mortality; however, attempting to determine when outbreaks will occur is difficult. Lowered resistance of trees appears to be a contributing factor. Overstocking and the increased presence of fir on sites that were once occupied by pine species may also contribute to higher than normal levels of fir mortality. Several insect predators, parasites and woodpeckers are commonly associated with the fir engraver and may help in control of populations at endemic levels.

Douglas-fir tussock moth

The Douglas-fir tussock moth is an important defoliator of true firs, primarily white fir, in California. Some level of outbreak by Douglas-fir tussock moth has been recorded in California about every 10 years. Outbreaks appear to develop almost explosively, and then usually subside abruptly after a year or two. Defoliation by the tussock moth kills or top-kills many trees, weakens additional trees that can be eventually killed by bark beetles, and may retard tree growth for several years.

Usually the first indication of attack appears in late spring. Larvae from the newly hatched eggs feed on current year's foliage, causing it to shrivel and turn brown. Older larvae may feed on both current and old foliage, although current needles are preferred. Defoliation occurs first in the tops of the trees and the outermost portions of the branches, and then in the lower crown and farther back on the branches.

The adult male is a gray-brouwn to black-brown moth with feathery antennae and a wingspread of 1 to 1 1/4 inches. The forewings are gray brown and have two distinct, irregular dark bars and two vague whitish spots. The hindwings are a contrasting brown. The female has tiny rudimentary wings, small threadlike antennae, and a large abdomen. Young larvae are 1/8 to 1/4 inch long and have long, fine body hairs which later develop into tufts. Mature larvae are up to 1 1/4 inches long and very colorful. Two long, dark tufts or pencils of hair similar to horns are located right behind the head. Four dense, buff colored tussocks are located forward along the middle of the back. The rest of the body except for the legs and head, is covered with short hairs radiating from red, buttonlike centers.

The tussock moth produces one generation each year. Females mate soon after they emerge from their pupal cocoon. Egg hatch in May or early June coincides with bud burst and shoot elongation of the host trees. The larvae pass through four to six instars and pupate toward the end of the summer. The pupal stage lasts from 10-18 days depending on temperature.

Many natural controls exist that keep the number of tussock moths low most of the time. If population levels are causing unacceptable resource damage, alternate methods of control are available. Management recommendations to prevent tree damage from tussock moth outbreaks involve four major activities: early detection, evaluation, suppression, and prevention. An early detection pheromone trap monitoring system is in place in California, however prevention is the ultimate goal of pest management. Silvicultural systems that reduce the number of susceptible hosts and decrease the multi-storied characteristics of host stands are recommended to prevent outbreaks. There is some indication that fir growing in pine sites an fir stands on warm, dry sites are most susceptible to damage.

Heterobasidion root disease

Heterobasidion spp. is a fungus that attacks a wide variety of woody plants. All western conifer species are susceptible. Madrone (*Arbutus menziesii*), and a few brush species (*Arctostaphylos spp.* and *Artemisia tridentata*) are occasional hosts. Other hardwood species are apparently not infected. The disease has been reported on all National Forests in California, with incidence particularly high on true fir in northern California, in the eastside pine type forests, and in southern California recreation areas.

Heterobasidion root disease is one of the most important conifer diseases in Region 5. Current estimates are that the disease infests about 2 million acres of commercial forestland in California, resulting in an annual volume loss of 19 million cubic feet. Other potential impacts of the disease include: increased susceptibility of infected trees to attack by bark beetles, mortality of infected trees presently on the site, the loss of the site for future production, and depletion of vegetative cover and increased probability of tree failure and hazard in recreation areas.

During periods favorable to the fungus, fruiting bodies (conks) form in decayed stumps, under the bark of dead trees, or under the duff at the root collar. New infection centers are initiated when airborne spores produced by the conks land and grow on freshly cut stump surfaces. Infection in true fir may also occur through fire and mechanical wounds, or occasionally, through roots of stumps in the absence of surface colonization. From the infected stump surface, the fungus grows down into the roots and then spreads via root-to-root contact to adjacent live trees, resulting in the formation of large disease centers. These infection centers may continue to enlarge until they reach barriers, such as openings in the stand or groups of resistant plants. In pines, the fungus grows through root cambial tissue to the root crown where it girdles and kills the tree. In true fir and other non-resinous species, the fungus sometimes kills trees, but more frequently is confined to the heartwood and inner sapwood of the larger roots. It then eventually extends into the heartwood of the lower trunk and causes chronic decay and growth loss.

Heterobasidion root disease in western North America is caused by two species: *Heterobasidion occidentalis* (also called the 'S' type) and *H. irregularis* (also called the 'P' type). These two species of *Heterobasidion* have major differences in host specificity. *H. irregularis* ('P' type) is pathogenic on ponderosa pine, Jeffrey pine, sugar pine, Coulter pine, incense cedar, western juniper, pinyon, and manzanita. *H. occidentalis* ('S' type) is pathogenic on true fir, spruce and giant sequoia. This host specificity is not apparent in isolates from stumps; with *H. occidentalis* being recovered from both pine and true fir stumps. These data suggest that infection of host trees is specific, but saprophytic colonization of stumps is not. The fungus may survive in infected roots or stumps for many years. Young conifers established near these stumps often die shortly after their roots contact infected roots in the soil.

Dwarf mistletoe

Dwarf mistletoes (*Arceuthobium* spp.) are parasitic, flowering plants that can only survive on living conifers in the Pinaceae. They obtain most of their nutrients and all of their water and minerals from their hosts.

Dwarf mistletoes spread by means of seed. In the fall the fruit ripen and fall from the aerial shoots. The seeds are forcibly discharged. The seed is covered with a sticky substance and adheres to whatever it contacts. When a seed lands in a host tree crown, it usually sticks to a needle or twig, where it remains throughout the winter. The following spring the seed germinates and penetrates the twig at the base of the needle. For the next 2-4 years, the parasite grows within the host tissues, developing a root-like system within the inner bark and outer sapwood, and causing the twig or branch to swell. Aerial shoots then develop and bear seed in another 2-4 years.

Dispersal of dwarf mistletoe seeds is limited to the distance the seeds travel after being discharged. From overstory to understory, this is usually 20 to 60 feet, but wind may carry them as far as 100 feet from the source. A rule of thumb is that the seeds can travel a horizontal distance equal to the height of the highest plant in an infected tree. There is some evidence that long distance spread of dwarf mistletoe is occassionaly vectored by birds and animals.

Vertical spread within tree crowns of most dwarf mistletoes is limited to less than one foot per year because of foliage density. Because of the thin crowns of gray pine, however, the vertical rate of spread has been measured as being greater than 2 feet per year. This rate of spread equalled or exceeded the rate of height growth of infected trees.

Dwarf mistletoes are easy to identify because they are generally exposed to view within a tree's crown. Signs of infection include the yellow-green to orange mistletoe plants, basal cups on a branch or stem where the plants were attached and detached plants on the ground beneath an infected tree. Symptoms include spindle-shaped branch swellings, witches' brooms in the lower crown, and bole swellings.